

# Perceptions vs. Reality: Measuring of Pleural Fluid pH in North Carolina

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## Abstract

**Background:** Pleural fluid pH anaerobically handled and measured by a blood gas analyzer (BGA) is used to define a pleural space infection as complicated and predict the life expectancy of patients with malignant pleural effusions. Pleural fluid pH can also be measured by other less accurate methods. It is unknown whether physicians who use pleural fluid pH measurements are aware of the method used by their laboratories.

**Methods:** We surveyed 90 pulmonary physicians in North Carolina about their use of pleural fluid pH and their hospital laboratory's approach (pH indicator stick, pH meter, or BGA). We then contacted their hospital laboratories to determine the actual method of pH measurement.

**Results:** Twenty-eight (31%) pulmonologists in 11 North Carolina hospitals responded on their use of pleural fluid pH. Of the 20 pulmonologists who order pleural fluid pH, 90% reported that their hospital measures pleural fluid pH via BGA, but the majority (72%) were inaccurate. Only two of 11 hospitals reported that they measure pleural fluid pH with a BGA.

**Conclusion:** Almost two-thirds of the chest physicians that order pleural fluid pH to help manage pleural effusions were using information that is not substantiated by the literature and, despite previous reports, hospitals still use suboptimal methods to measure pleural fluid pH. Further information is needed concerning the barriers to physicians and laboratory practices concerning the use of BGA for the measurement of pleural fluid pH.

**Keywords:** pleural effusion; pleural fluid pH; complicated parapneumonic effusion; malignant pleural effusion

It is estimated that there are four million cases of community-acquired pneumonia in the United States annually with one-quarter requiring hospitalization.<sup>1</sup> Parapneumonic effusions complicate the course of 57% of patients with bacterial pneumonia.<sup>2-4</sup> Coupled with other clinical information, the measurement of the pleural fluid pH is important in the management of pleural space infections and malignant pleural effusions.<sup>2-17</sup> Appropriate management using pleural drainage may decrease hospitalization, prolonged systemic toxicity, ventilatory impairment, further spread of the inflammatory reaction, and possible mortality.<sup>6</sup> Light and Sahn reported that

a pleural fluid pH of less than 7.1 defined the pleural effusion as complicated and predicted that pleural drainage would be necessary to avoid pleural fibrosis and resolve pleural sepsis, whereas a pH  $\geq$  7.3 would predict resolution with systemic antibiotics alone.<sup>12,17</sup> Jiménez Castro and colleagues have demonstrated that pleural fluid pH has the highest diagnostic accuracy for identifying complicated parapneumonic effusions.<sup>11</sup> The most recent American College of Chest Physicians (ACCP) consensus panel on the medical and surgical management of parapneumonic effusions recommends that pleural fluid pH is the preferred

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pleural fluid chemistry test and should be measured via blood gas analyzer.<sup>6</sup> In patients with a malignant pleural effusion, a pleural fluid pH of less than 7.3 may suggest that the patient has a limited life expectancy from the time of diagnosis and may fail chemical pleurodesis.<sup>8,10,18-21</sup> Although the accurate measurement of pleural fluid pH is relevant to the care of patients with complicated pleural fluid infections and malignant pleural effusions, there has been little reported about the use and knowledge of this measurement by chest physicians.

Three methods with unique performance characteristics are commonly used to measure pleural fluid pH: blood gas analyzer (BGA), pH meter, and pH indicator stick.<sup>22,23</sup> Cheng and Lesho have demonstrated that the measurement of pleural fluid pH with a blood gas analyzer is the most accurate of these, but other methods are used widely.<sup>22,23</sup> Chandler and associates reported that 68% of hospital laboratories in the southeastern United States measured the pleural fluid pH with either pH indicator stick or pH meter and not by BGA.<sup>24</sup> In a similar national survey of 220 hospital laboratories, Kohn and colleagues also reported varied approaches: pH meter (35%), BGA (32%), and pH indicator stick (31%).<sup>25</sup>

The laboratory measurement of pleural fluid pH with any method other than a BGA poses problems for the practicing physician. If the sample is not measured by a method that is validated in the literature, then the resulting data may not be appropriate to guide clinical decisions. The use of pH meter or indicator stick can overestimate pH.<sup>22</sup> This may lead to a diagnostic misclassification of the effusion, a potential underestimation of the gravity of the problem, and undertreatment of the condition. Furthermore, if the physician believes that the sample is being measured by the standard method that has been validated in the literature (BGA), but in fact it is not, then an inappropriate clinical decision may be made.

The goal of this study was to determine the knowledge of practicing pulmonologists about the measurement of pleural fluid pH by hospital laboratories and the actual methods used to measure pleural fluid pH by their own hospital laboratories.

## Methods

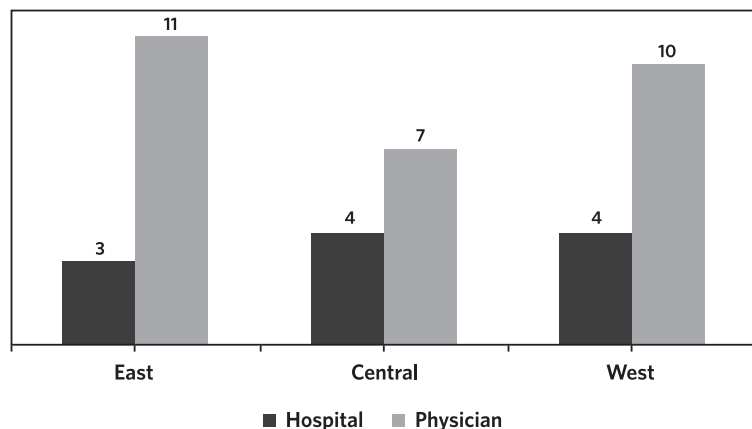
From July of 2006 to September of 2006 we contacted 90 pulmonary physicians in North Carolina, identified by registration with the North Carolina Medical Board and membership with the American College of Chest Physicians (ACCP), via email, fax, or telephone. We then asked them to complete a survey concerning their use of pleural fluid pH in patients with pleural effusions and to report how their hospital laboratory measures pleural fluid pH from a list of three methods: pH indicator stick, pH meter, or BGA. We then contacted the individual hospital laboratories (within 30 days of receiving the physician's

responses) used by these pulmonologists and asked what method they used to measure pleural fluid pH: pH indicator stick, pH meter, or BGA. Each laboratory and physician was contacted only once. This study was approved by the Wake Forest University School of Medicine Institutional Review Board.

## Results

Thirty-one percent (28/90) of the surveyed North Carolina pulmonary physicians responded to our questionnaire and practiced at 11 different North Carolina hospitals (100% of the hospitals were contacted; 11/11), including 2 university medical centers. Physicians and hospitals were distributed across the state (see Figure 1). Proportions of responses by physicians and laboratories were calculated reported, and compared to one another (see Table 1). The responses to each question are summarized below.

**Figure 1.**  
**Number of North Carolina Hospital Laboratories and Pulmonologists Surveyed Per Region**



### Do you order pleural fluid pH?

Seventy-one percent (20/28) of respondents reported that they order pleural fluid pH and 28.6% (8/28) reported they do not.

### To your knowledge, how does the hospital laboratory measure the pleural fluid pH: pH indicator stick, pH meter, or through a blood gas analyzer?

Seventy-five percent (21/28) of responding pulmonologists reported that their hospital laboratory measures pleural fluid pH by BGA, 3.6% (1/28) by pH indicator stick, 3.6% (1/28) by pH meter, and 17.9% (5/28) did not know how their hospital measures the pleural fluid pH (see Figure 2).

### Pleural fluid pH measurement by North Carolina hospitals

Eighteen percent (2/11) of the hospitals surveyed (one of two of the university medical centers) reported that they measure pleural fluid pH by BGA, 36.4% (4/11) by pH meter, and 45.5% (5/11) by pH indicator stick (see Figure 2).

**Table 1.**  
**Pulmonologist Perception of pH Measurement**  
**in 11 North Carolina Hospitals**

Hospital	Pulmonologists surveyed	Perceived method of pH measurement	Actual pH measurement	Percentage of physicians who were correct in their perception of pH measurement
1	1	IS	IS	100%
2	1 <sup>a</sup>	DNK	MT	0%
3	3	BGA	MT	0%
4	1	BGA	MT	0%
5	2	BGA	BGA	100%
6	1	BGA	IS	0%
7	3	BGA	IS	0%
8	1	BGA	IS	0%
9	3	BGA	BGA	100%
10	7 <sup>b</sup>	5 BGA 1 MT 1 DNK	MT	14%
11	5 <sup>c</sup>	2 BGA 3 DNK	IS	0%

a This physician did not order pleural fluid pH.

b Two out of these seven pulmonologists did not order pleural fluid pH.

c None of these pulmonologists ordered pleural fluid pH.

IS = Indicator stick DNK= Did not know BGA = Blood gas analyzer MT = pH meter

## Discussion

Our survey has demonstrated that the majority of responding pulmonary physicians in North Carolina order pleural fluid pH, but there is a substantial discrepancy between the clinicians' perceptions of the method measurement of pleural fluid pH by their hospital laboratories and the actual method; only 30% of the ordering pulmonary physicians knew the method used by their own hospital laboratory. Most of the surveyed physicians (75%) believed that the pH was being measured by BGA (the approach consistent with the literature<sup>6,7,9-12,15-17,20,21</sup>) but of these, 72% were mistaken about the method used. To our knowledge, this is the first report of discordance between pulmonologist perceptions and the reality concerning the measurement of pleural fluid pH. This implies that clinical decisions could be made based on data that is not supported by the literature. Furthermore, our data is consistent with previous reports that laboratories continue to use methods other than BGA to measure pleural fluid pH.<sup>24,25</sup>

### Accuracy of physicians perceptions of pleural fluid pH by North Carolina hospitals

Fifty-seven percent (16/28) of the respondents had inaccurate perceptions of how pleural fluid pH was measured by their hospital laboratory, 25% (7/28) were accurate, and 17.9% (5/28) did not know how the pleural fluid pH is measured by their hospital.

Of the physicians who order pleural fluid pH, 30% (6/20) had accurate knowledge of how their hospital measures pleural fluid pH (83% or 5/6 BGA; 17% or 1/6 pH indicator stick), and 70% (14/20) had inaccurate perceptions of how pleural fluid pH was measured. Most (18/20, or 90%) of the pulmonologists who ordered pleural fluid pH perceived that the hospital laboratory was using a BGA, but 72% (13/18) were inaccurate in this belief. For these physicians (those who order pleural fluid pH and perceived the measurement was by BGA), the hospitals (n = 8) had varying approaches: 24% (2/8) of the hospitals actually measured pleural pH with a BGA, 37.5% (3/8) with a pH meter, and 37.5% (3/8) with a pH indicator stick.

Among the eight physicians who reported they do not order pleural fluid pH, only one knew their hospital's approach (pH meter).

Cheng and colleagues established the accuracy of the BGA in measuring the pH of pleural fluid handled in the ideal fashion (anaerobically with rapid measurement) and demonstrated that both pH meter and indicator stick significantly overestimated the pleural pH.<sup>22</sup> The mean pleural fluid pH measured by BGA was  $7.42 \pm 0.01$  compared to the mean pleural fluid pH measured by a pH meter and indicator stick of  $7.58 \pm 0.02$  and  $8.23 \pm 0.06$  respectively. Cheng also reported that the 95% confidence interval for the precision of the pH meter and indicator stick was  $\pm 0.26$  and  $\pm 0.80$  respectively.<sup>22</sup> Since the clinically significant change in pleural pH is approximately 0.3 pH units (pH 7.4 to < 7.1), neither the pH indicator stick nor the pH meter are precise enough to be clinically accurate. Although other clinical indicators of complex pleural pathophysiology are available and useful, if the pulmonologist is unaware or mistaken about the method of measurement, a discordant pleural pH result can lead to confusion and the test will not be cost effective. Yet, by our survey, a majority of North Carolina pulmonary physicians place value in this measurement while the minority of pleural pH measurements is done by the recommended method (BGA).

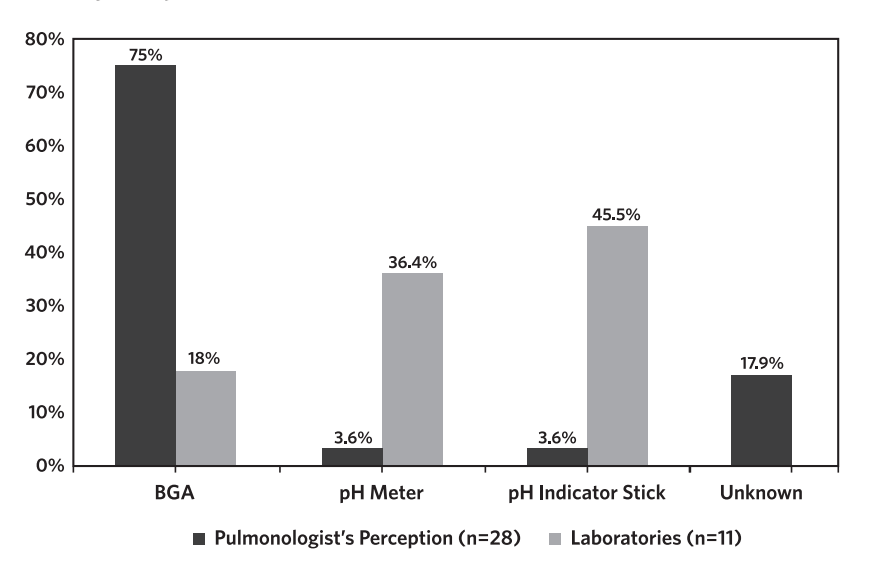
Eight of the 28 responding chest physicians reported that they do not use the measurement of pleural fluid pH to

characterize pleural fluid. The reasons for the under use of this potentially helpful test are unclear and might reflect perceived technical difficulties or inconvenience in anaerobic handling of specimens; however we did not address this in our study. Additionally, three of these physicians (those that do not order pleural fluid pH) believed that their hospital laboratory used BGA to measure pleural fluid pH, which suggests that they may have had concerns other than the perceived inaccuracy of the approach to measurement. One can speculate that this may be due to their reliance upon other measures, perhaps substituting LDH or glucose instead of pH, in characterizing complicated pleural effusions or other undefined factors.<sup>6,9</sup> Heffner and colleagues reported that pleural fluid pH was measured in 28 of 38 patients with complicated parapneumonic effusions and in only 5 out of 10 patients who underwent “delayed” pleural fluid drainage.<sup>2</sup> More information is needed regarding barriers to physician’s use of pleural fluid measurements.

Interestingly, only 2 of our 11 surveyed hospitals in North Carolina use a BGA to measure pleural fluid pH. This is consistent with Chandler’s finding that 32% of laboratories in the Southeastern United States used a BGA to measure the pH of pleural fluid.<sup>24</sup> Selected laboratories we surveyed volunteered several concerns, although it was not a routine part of our formal questioning. These included reports that the protein content in the exudative pleural fluid possibly obstructed or damaged the BGA (a belief reported by Lesho and Chandler).<sup>23,24</sup> While it is clear that frank pus should not be evaluated for pleural fluid pH (nor should it be needed), it is unlikely that the protein content alone can damage these machines since the protein content of pleural fluid is less than whole blood.<sup>24,26</sup> Additionally, some of the laboratories volunteered that the manufacturers warn that the BGA is validated only for whole blood and that the measurement of pleural fluid pH by a BGA is not FDA-approved (except for one BGA by Roche, the OMNI). The measurement of pleural fluid pH by a non-FDA approved BGA is considered a complex test (defined by adherence to strict guidelines for precision and accuracy testing) by the Clinical Laboratory Improvement Amendments (CLIA). Further information is needed about barriers to BGA use by hospital laboratories but one may relate to the cost effectiveness to perform a complex test.

There are several limitations to our study. The number of pulmonologists we surveyed was small (28 of 90), and these findings may be biased by selective responses and may not be a valid estimate of North Carolina pulmonologists or chest physicians outside of North Carolina. However, our response rates are similar to those reported in literature.<sup>27</sup> We did not

**Figure 2.**  
**Comparison of Pulmonologist’s Perception of Pleural Fluid pH Measurement by Their Hospital Laboratory and the Actual Method Used by Hospital Laboratories**



investigate why some pulmonologists do not order pleural fluid pH. Further, we did not examine how the sample was collected and if it is handled and processed in an anaerobic manner, factors which influence the accuracy of the test. Venkatesh demonstrated that aerobic storage of pleural fluid resulted in a clinically important overestimation of pleural fluid by pH meter and BGA of 0.14 – 0.16 pH units ( $p < 0.05$ ). He felt that both anaerobic handling of the specimen and rapid measurement throughout the process (albeit difficult in real practice) were the keys to accuracy especially if utilizing a pH meter to measure pleural pH.<sup>28</sup> We did not make a routine part of our questioning to the hospital laboratories as to why they use a particular method to measure pleural fluid pH as our goal was to determine the method used by the laboratories and if the pulmonologist was aware of the method of pH measurement. Only pleural fluid pH measured by BGA has been validated by clinical investigations.<sup>2,5-7,9-12,15,16,18-21,29</sup>

We found that the majority (75%) of pulmonologists either did not know how pleural fluid pH was measured by their hospital laboratory (17.9%) or had inaccurate perceptions concerning the measurement of pleural fluid pH by North Carolina hospitals (57%). Fundamentally, the clinical value of a test is in its validation in a particular clinical scenario. Pleural fluid pH is useful in the management of complex pleural effusions; however, its value is diminished when it is measured by methods other than a BGA which may lead to erroneous management decisions especially if the clinician is unaware of the inaccuracy of the test when a BGA is not utilized. This represents a lost opportunity to improve the care of patients with pleural effusions. If these findings are confirmed, the barriers to more optimum practices by physicians and laboratories should be identified and corrected. **NCMJ**

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